Scientific Inquiry

7-1 The student will demonstrate an understanding of technological design and scientific inquiry, including the process skills, mathematical thinking, controlled investigative design and analysis, and problem solving.

7-1.3 Explain the reasons for testing one independent variable at a time in a controlled scientific investigation.

Taxonomy Level: 2.7-C Understand Procedural Knowledge

Previous/Future knowledge: In 3rd grade (3-1.7), students explained why similar investigations might produce different results. In 4th grade (4-1.3), students summarized the characteristics of a simple scientific investigation that represent a fair test (including a question that identifies the problem, a prediction that indicates a possible outcome, a process that tests one manipulated variable at a time, and results that are communicated and explained). In 5th grade, students identified independent (manipulated), dependent (responding), and controlled variables in an experiment (5-1.2) and planned and conducted controlled scientific investigations, manipulating one variable at a time (5-1.3). In 8th grade, students will recognize the importance of a systematic process for safely and accurately conducting investigations (8-1.2) and will explain the importance of and requirements for replication of scientific investigations (8-1.5).

It is essential for students to know that a *controlled scientific investigation* determines the effect of an independent variable in an experiment, when all other variables are controlled. Every controlled scientific investigation provides information. This information is called *data*. Data includes both scientific observations and inferences.

- A *scientific observation* is gained by carefully identifying and describing properties using the five senses or scientific tools and can be classified as *quantitative* or *qualitative*.
  - Quantitative observations are observations that use numbers (amounts) or measurements (including the unit label) or observations that make relative comparisons, such as more than, all, less than, few, or none.
  - Qualitative observations are observations that are made using only the senses and refer to specific properties.
- An *inference* is an explanation or interpretation of an observation based on prior experiences or supported by observations made in the investigation. They are not final explanations of the observation. There may be several logical inferences for a given observation. There is no way to be sure which inference best explains the observation without further investigation.

In order to design a *controlled scientific investigation* some or all of the following steps should be included:

- Identify a testable question (tests one variable) that can be investigated
- Research information about the topic
- State the hypothesis as a predicted answer to the question, what may be the possible outcome of the investigation
- Design an experiment to test the hypothesis, controlling all variables except the independent (manipulated) variable
  - Plan for independent (manipulated) and dependent (responding) variables with repeated trials
  - Plan for factors that should be held constant (controlled variables) and/or plan for a control set-up
  - List the materials needed to conduct the experiment
  - List the procedures to be followed
  - Plan for recording, organizing and analyzing data

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- Conduct the experiment and record data (observations) in tables, graphs, or charts
- Analyze the data in the tables, graphs, or charts to figure out what the data means (describe the relationship between the variables)
- Compare the results to the hypothesis and write a conclusion statement that will support or not support the hypothesis based on the recorded data
- Communicate the results to others

It is also essential for students to know that if there is only one independent (manipulated) variable, then there is only one factor that can affect the results of an experiment.

- Before beginning an investigation, all potential factors that could affect the results should be listed. From this list, the independent (manipulated) variable should be determined while planning to control all other variables.
- Once the independent (manipulated) variable is identified, then all other factors that may influence the experiment need to be controlled.
- When more than one variable is allowed to affect the dependent (responding) variables or the outcome of the investigation, then a fair test is not conducted.
- When more than one factor at a time is changed, reasonable conclusions cannot be made.
- A controlled variable is kept constant so that it does not affect the outcome of the experiment.
- Some experiments may have a control set-up (or group) so that the experimental results can be compared to the control results.
    - The control set-up (or group) is treated like the experimental group except the independent (manipulated) variable is not applied.

It is not essential for students to evaluate an investigation as to how it was planned and conducted.

It is also essential for students to know that science is the process of learning about the natural world by asking questions and trying to find the answers to those questions. Technology applies scientific knowledge in order to develop a solution to a problem or create a product to help meet human needs. Technology is usually developed because there is a need or a problem that needs to be solved. Steps in the technological design process include:

- *Identifying a problem or need*
    - Research and gather information on what is already known about the problem or need
- *Designing a solution or a product*
    - Generate ideas on possible solutions or products
    - Evaluate the factors that will limit or restrict the solution or product design
    - Determine the trade-offs of the solutions or products (what must be given up in order to create the solution or product)
- *Implementing the design*
    - Build and test the solution or product
    - Identify any problems with the solution or product
    - If necessary, redesign the solution or product to eliminate any problems in the design
- *Evaluating the solution or the product*
    - Determine if the solution or product solved the problem
    - Identify the pros and cons of the solution or product

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The steps of the design can be communicated using descriptions, models, and drawings.

- A *scientific model* is an idea that allows us to create explanations of how the something may work. Models can be physical or mental.

It is not essential for students to compare the processes of a controlled scientific investigation and the technological design process or evaluate a technological design or product on the basis of designated criteria (including cost, time, and materials).

Assessment Guidelines:
The objective of this indicator is to *explain* the reasons for testing one independent variable at a time in a controlled scientific investigation; therefore, the primary focus of assessment should be to construct a cause-and-effect model of why only one independent variable should be tested. However, appropriate assessments should also require students to *identify* reasons for controlling variables in an investigation; *identify* the variables in an investigation; *recognize* an investigation that tests only one independent variable; *compare* the control set-up to the experimental design; *summarize* the steps of a controlled scientific investigation; *exemplify* technology; *match* a specific solution or product to a specific need or problem; or *summarize* the steps in the technological design process.